Historic, archived document

Do not assume content reflects current scientific knowledge, policies, or practices.

CIRCULAR No. 378 NOVEMBER 1935
UNITED STATES DEPARTMENT OF AGRICULTURE
WASHINGTON, D. C.

A PRACTICAL LABORATORY METHOD OF MAKING THIN CROSS SECTIONS OF FIBERS

By J. I. Hardy, *senior animal husbandman, Animal Husbandry Division, Bureau of Animal Industry*

CONTENTS

	Page
Introduction	1
Improved device and equipment	2
Sectioning procedure	3
Cross sections of fibers of different types	4
Application of the method	10
Summary	10

INTRODUCTION

Fiber research has long been handicapped by the need of a method for obtaining good cross sections quickly. Ordinarily they are made with a microtome after the fibers have been embedded in some suitable medium such as paraffin or celloidin. Good results may be obtained with such embedding methods but from 2 to 3 days' time is required. Barker and Burgess, as cited by Barker,[2] coated bundles of wool fibers with celloidin and then embedded them in beeswax after they had been stretched in a mounting frame to hold the fibers as nearly parallel as possible. Hotte[3] sectioned individual fibers after coating them with successive layers of celloidin, bayberry wax, and paraffin. Such methods are necessarily limited in their application because of the time and expense involved. It is extremely difficult to control the position of many kinds of fibers in the embedding mediums so that accurate cross sections may be made.

Through the use of a recent invention by the writer, a simple laboratory technic has been developed, in the animal-fiber laboratory of the Bureau of Animal Industry, for quickly making thin cross sections of fibers with better definition than is ordinarily obtained by more laborious methods used in conjunction with a microtome. It is an improvement over the method reported by the writer

---

[1] The writer extends thanks to J. O. Grandstaff, junior animal fiber technologist of the Animal Husbandry Division, for assistance in making the cross sections.

[2] Barker, S. G. wool quality; a study of the influence of various contributory factors, their significance and the technique of their measurement. 333 pp., illus. London. 1931. See p. 114.

[3] Hotte, G. H. the fiber candle improved to permit quicker and better preparation of specimens for microscope. Textile World 85: 1063–1064, illus. 1935.

21838°—35

in earlier publications.[4] The former method, which produced cross sections about one sixty-fourth of an inch thick, depended largely for its efficacy upon the translucence of fibers, thus limiting its application primarily to white fibers of wool and mohair.

In the cutting of thicker cross sections of very fine wool, red celluloid solution was applied to the ends of the fibers, which had been allowed to project slightly beyond the surface of one side of the fiber holder. After being dried, the celluloid containing the ends of the fibers was cut off close to the holder. The purpose of the red celluloid was to obtain better contrast when the section was projected. It was in this connection that the writer discovered, through a process of trial and error, that good thin cross sections might be obtained, which, when mounted in balsam, gave much better definition than was obtainable with the thick sections.

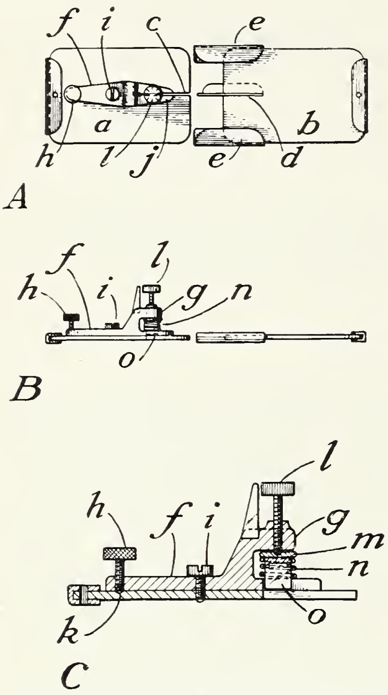

FIGURE 1.—Device for holding fibers for cutting cross sections: *A*, Top view of entire device; *B*, side view of entire device; *C*, detailed view of the mechanism for propelling fibers through the fiber slot.

IMPROVED DEVICE AND EQUIPMENT

In this method the cross sections are obtained through the use of the device illustrated in figure 1. Both the fiber holder (*a*) and slide holder (*b*) are three sixty-fourths of an inch in thickness. The shape of the fiber holder and slide holder when assembled is that of an ordinary microscope slide, 1 inch wide and 3 inches long, the fiber holder and slide holder each being 1.5 inches long. The width of the fiber slot (*c*) is 0.0085 inch and its length is three-eighths of an inch. The fiber slide (*d*) is strengthened by two supporting guides (*e*).

The device has three main parts. The first of these is a fiber holder (*a*), in the middle of which a fiber slot (*c*) is cut extending three-eighths of an inch toward its center. The second part is designated as the slide holder (*b*), in which is rigidly held a flat-surfaced metal slide (*d*) with a right-angled flange. This slide extends sufficiently beyond the slide holder so that when the slide is in position the width of the unfilled span in the bottom of the slot is one-eighth of an inch. On each side of the slide holder is a guide (*e*) which keeps the fiber holder steady and the surfaces of the fiber and slide holders in the same plane. These guides also help hold the fiber holder and slide holder together.

---

[4] HARDY, J. I. DETERMINATION OF FIBRE FINENESS. A RAPID METHOD USING A NEW CROSS-SECTIONING DEVICE. Textile Research 3: 381–387, illus. 1933.

——— DETERMINATION OF FIBRE FINENESS AND CROSS-SECTIONAL VARIABILITY; AN IMPROVED TECHNIQUE FOR OBTAINING PHOTOMICROGRAPHS BY PROJECTING CROSS-SECTIONS ON SENSITIZED PAPER. Textile Research 5: 184–190, illus. 1935.

The third part of the device is the means by which the fibers are pushed through the fiber slot and consists of a metal swivel (*f*) with an overhanging arm (*g*) on one end and a set screw (*h*) on the other. The metal swivel is attached to a central point (*i*) of the fiber holder. Through one end of the swivel is a slot (*j*) which is in perfect alignment with the base end of the fiber slot (*c*) when the set screw (*h*) on the other end of the swivel fits into a countersunk hole (*k*) in the end of the fiber holder opposite the fiber slot. Through the overhanging arm of the swivel is a small screw (*l*) for propelling a metal plunger through the slot on the end of the swivel and also through the fiber slot. At the top of the metal plunger is a metal disk with a countersunk hole (*m*) at its center point into which the propelling screw fits. Just under the metal disk is a tension spring (*n*) which holds the metal plunger (*o*) against the propelling screw. The circumference of the head of the propelling screw is calibrated to assist the operator in controlling the movement of the plunger. The other equipment consists of a laboratory and a dissecting microscope, ordinary safety-razor blades, a celluloid solution the consistence of corn sirup made by dissolving celluloid in acetone or some other celluloid solvent, glass slides, cover slips, tweezers, scissors, and a mounting medium such as Canada balsam or diaphane.

SECTIONING PROCEDURE

To operate the device the metal swivel is swung to one side after the fiber plunger and set screw have been released. A tuft of fibers is thoroughly cleaned with a solvent, such as ether or carbon tetrachloride, and dried between blotting paper. From this is separated a strand of fibers about one-eighth of an inch in diameter and containing a sufficient number to fill the slot to a depth of about three-sixteenths of an inch. This strand is inserted into the fiber holder, and the slide of the slide holder is pushed into the fiber slot until the tuft of fibers is held firmly. The fibers are then cut off flush on both sides of the fiber holder by means of a safety-razor blade having an edge observed to be keen and smooth, at 100 diameters' magnification. The swivel is swung into place and fastened into position with the set screw. The fiber plunger is propelled into the fiber slot by the propeller screw until the fibers are projecting through the slot about 0.01 inch. They are cut off flush with the surface of the fiber holder. The propeller screw is then advanced according to the desired thickness of the cross section, and a thin coating of celluloid solution is applied to the surface of the fibers and allowed to dry. The cross section is then cut off with a sharp razor blade. By means of tweezers the section is mounted with Canada balsam directly upon a glass slide and covered with a cover slip. A considerable number of cross sections may be made of the same fibers without refilling the slot of the fiber holder.

CROSS SECTIONS OF FIBERS OF DIFFERENT TYPES

Sections as thin as 0.0001 inch (about 3μ) can be obtained by the improved technic, making possible accurate examination for shape and structure of the most opaque animal and vegetable fibers. In animal fibers the thickness of cuticle and the size, shape, and distribution of pigment granules, where these are present, may be readily seen. The characteristic cross-sectional structure of vegetable fibers and rayon may also be observed as well as the presence or absence of dye in all fibers.

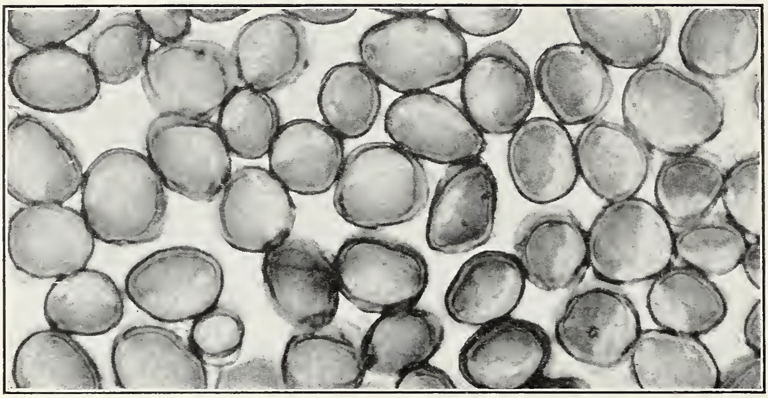

Figure 2.—Cross section of Merino wool fibers. The dark band around each fiber is the cuticle. ×500.

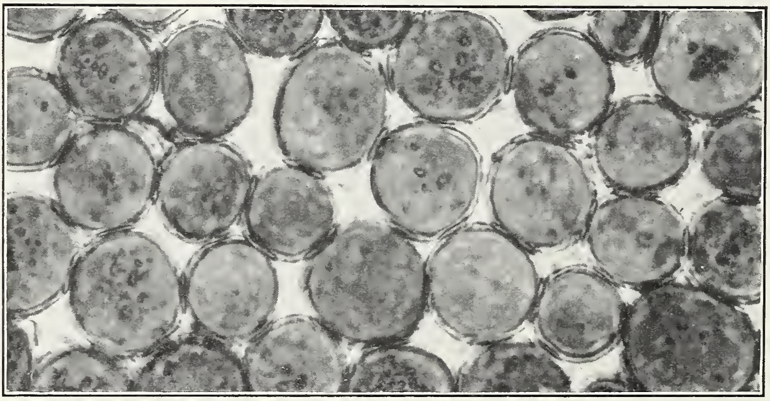

Figure 3.—Cross section of mohair fibers. The speckled appearance is due to minute spaces in the cortex of the fibers, visible in thin sections. ×500.

Figures 2 to 16, inclusive, show photomicrographs of cross sections of animal and vegetable fibers. They were all made at the same magnification in order to show the relative sizes of the different fibers. These thin cross sections make possible the study of some of the finer details of fiber structure. Figures 3 and 9, in particular, illustrate this point. The speckled appearance of the cross sections of mohair fibers in figure 3 is a structural characteristic of the cor-

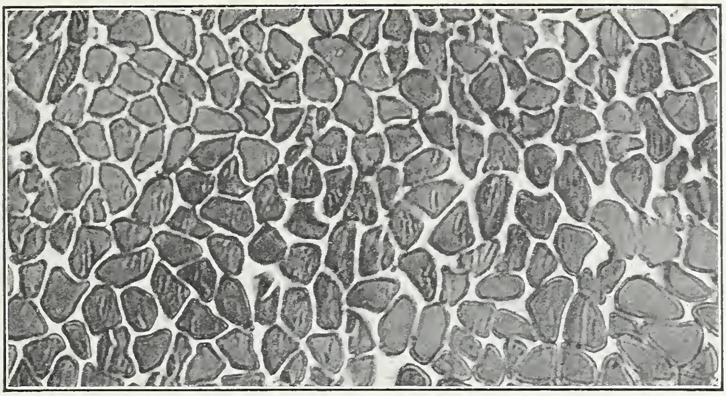

Figure 4.—Cross section of true silk. ×500.

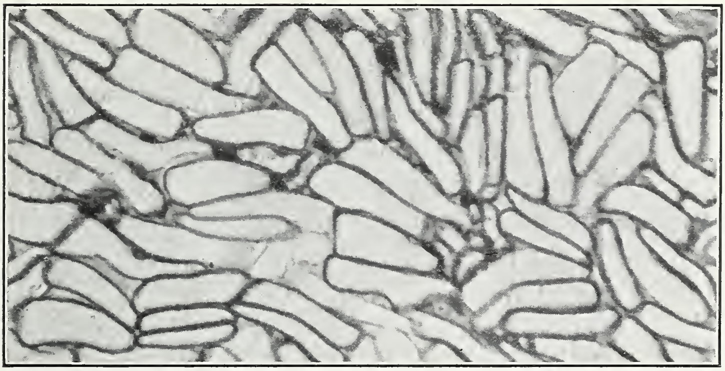

Figure 5.—Cross section of tussah silk (wild silk), more wedge shaped than the true silk shown in figure 4. ×500.

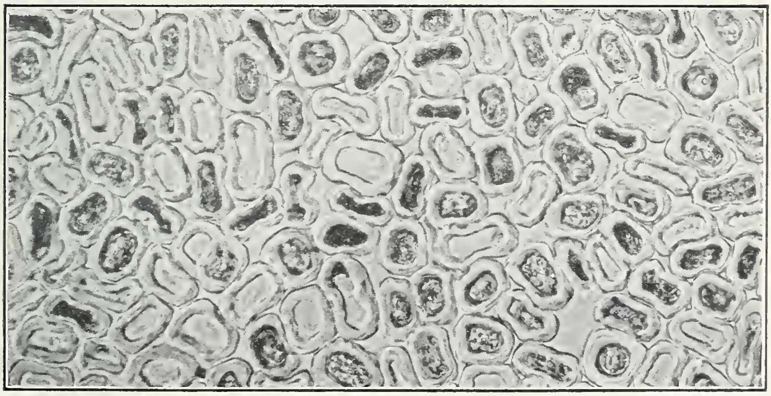

Figure 6.—Cross section of rabbit-fur fibers. ×500.

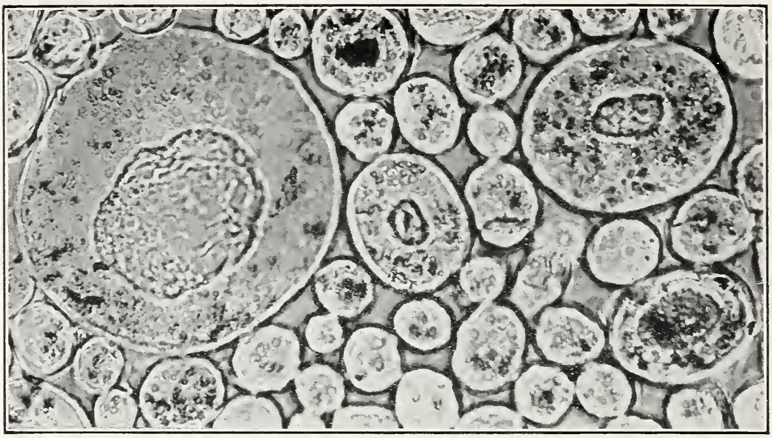

FIGURE 7.—Cross section of camel's hair. The very coarse fibers are from the outer coat, and the finer fibers are from the under coat. ×500.

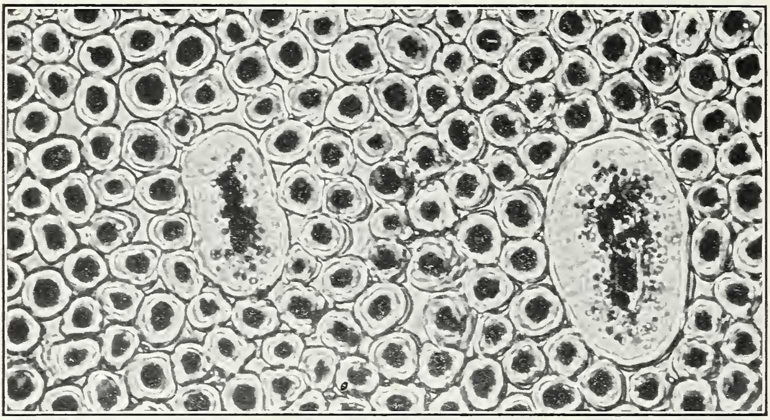

FIGURE 8.—Cross section of muskrat-fur fibers. The two large guard hairs show pigment granules. ×500.

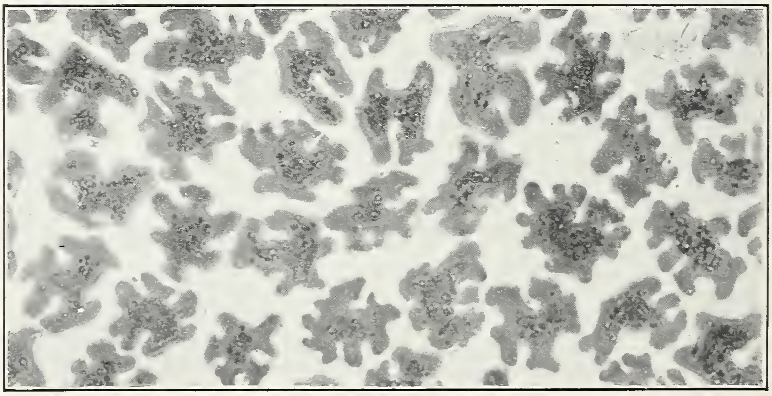

FIGURE 9.—Cross section of rayon fibers. The clusters of globules which appear on each cross section are due to a delustering agent used in the manufacture. ×500.

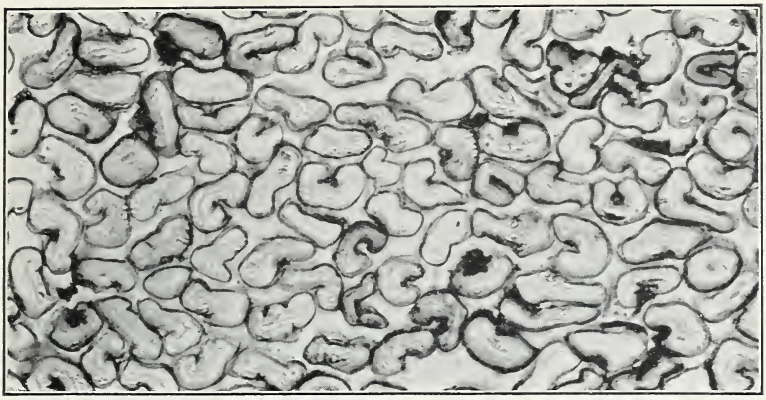

FIGURE 10.—Cross section of cotton fibers. ×500.

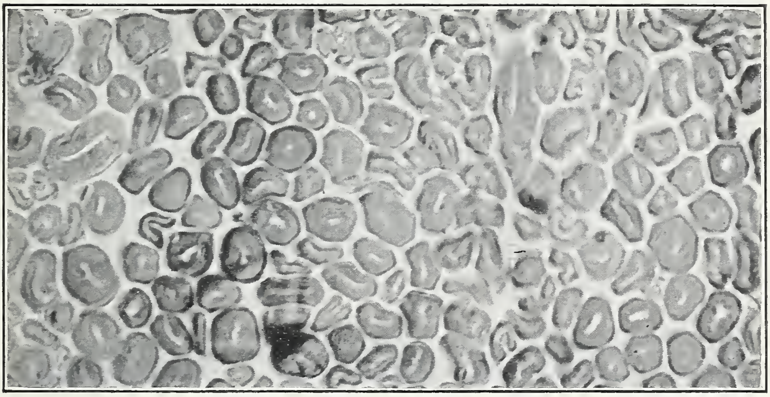

FIGURE 11.—Cross section of mercerized cotton fibers. ×500.

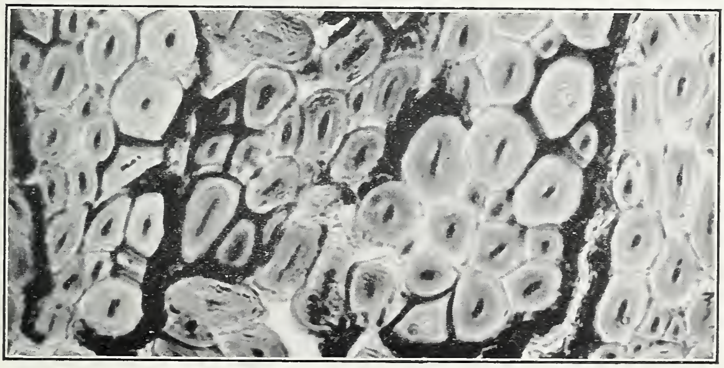

FIGURE 12.—Cross section of flax fibers. ×500.

tical layer of wool and mohair. Mark[5] refers to this structure as "holes" or "hollow spaces." Frölich, Spöttel, and Tänzer[6] stated that Hölliker observed these open spaces prior to 1835 and that they were later observed by several other German investigators.

The mohair fibers from which the cross section was made for figure 3 were dyed in safranin solution in order to obtain better definition in the photomicrograph. This dyeing process increased the visibility of the holes. Cross sections of wool and mohair chemically damaged by remanufacture—fibers such as are frequently found in shoddy mixtures—show these holes to be very pronounced. These open spaces may have a relationship to the warmth of wool and its good insulating qualities.

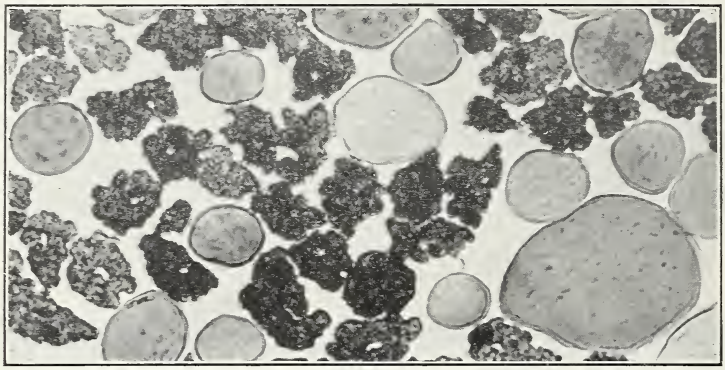

FIGURE 13.—Cross section of yarn from a German fabric containing 50 percent wool and 50 percent "vistra." Vistra is a new synthetic fiber used as a substitute for wool. The oval fibers are wool. ×500.

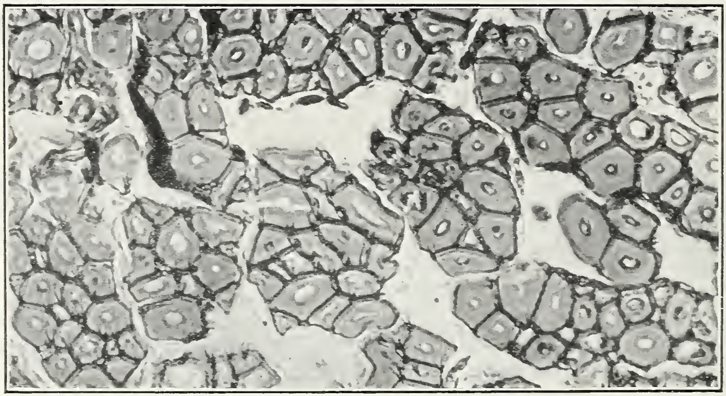

FIGURE 14.—Cross section of jute fibers. ×500.

The method is rapid; an experienced operator may obtain good cross sections in 10 minutes that would require more than a day's time with embedding methods.

---

[5] MARK, H. BEITRÄGE ZUR KENNTNIS DER WOLLE UND IHRER BEARBEITUNG. EXPERIMENTELLE UND METHODISCHE UNTERSUCHUNGEN . . . 146 pp., illus. Berlin. 1925.

[6] FRÖLICH, G., SPÖTTEL, and TÄNZER, E. WOLLKUNDE; BILDUNG UND EIGENSCHAFTEN DER WOLLE. 419 pp., illus. Berlin. 1929.

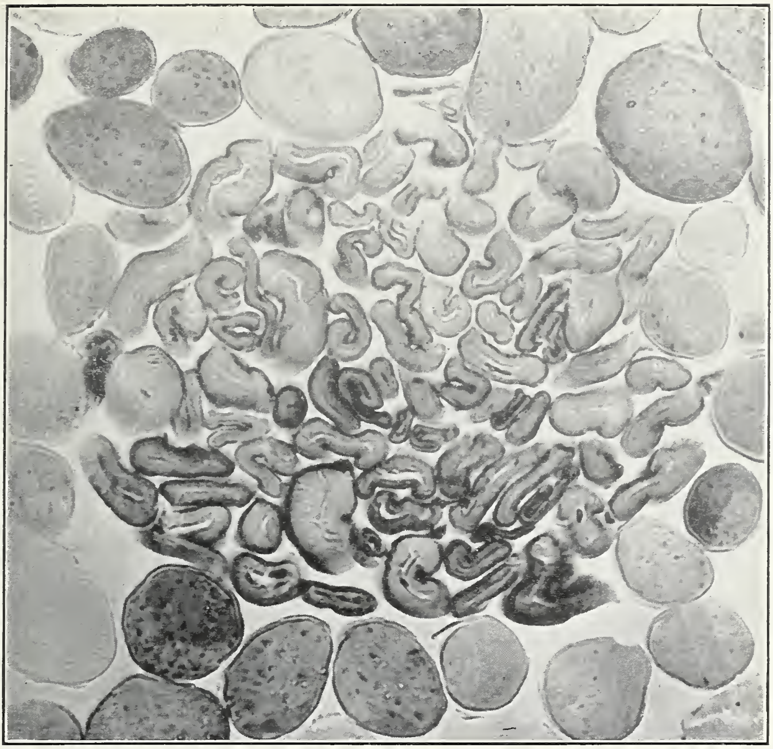

FIGURE 15.—Cross section of "cotton and worsted twist" yarn. Cross section was made without removing the twist from the yarn. The wool encircles the cotton, thereby making the resulting cloth appear to be all wool. ×500.

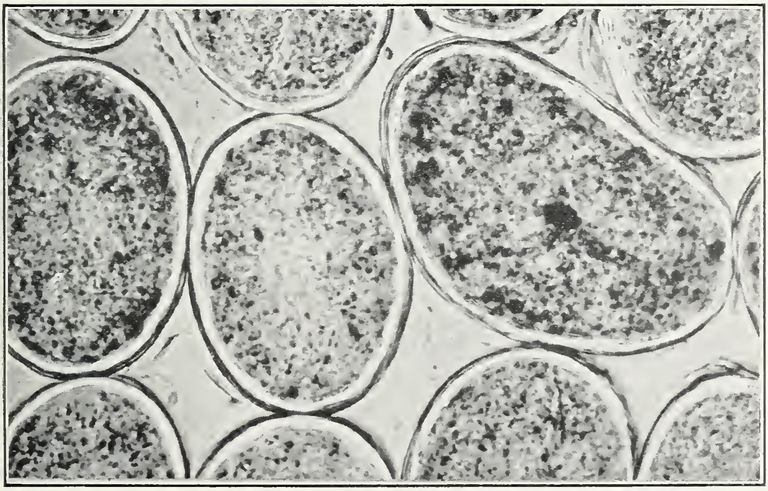

FIGURE 16.—Cross section of hair from the head of a woman 30 years old. Differences in the color of hair of different persons are due to the tiny pigment granules seen scattered through the section. ×500.

APPLICATION OF THE METHOD

The technic described offers important applications in the study of the shape, size, and cross-sectional characteristics of animal and vegetable fibers in connection with breeding and nutrition investigations. It also has an application in regulatory work, in which it is essential to have prompt identification of fiber mixtures and fabrics. Some application may also be made in connection with the identification of criminals, through their hair, fragments of clothing, and evidence of similar nature. The writer has applied for a patent, through official Department channels, with the view of having the device made available for agricultural, industrial, and other uses.

SUMMARY

A new and improved device and technic for making very thin cross sections of fibers are described and illustrated.

The laboratory equipment required is relatively inexpensive. Less skill is required than is needed to operate a microtome.

The method is rapid, a consideration which makes its use desirable where many samples must be examined in the course of a day.

The method is adapted to many branches of agriculture and industry for research, regulatory, and commercial purposes.

ORGANIZATION OF THE UNITED STATES DEPARTMENT OF AGRICULTURE WHEN THIS PUBLICATION WAS LAST PRINTED

Secretary of Agriculture	HENRY A. WALLACE.
Under Secretary	REXFORD G. TUGWELL.
Assistant Secretary	M. L. WILSON.
Director of Extension Work	C. W. WARBURTON.
Director of Personnel	W. W. STOCKBERGER.
Director of Information	M. S. EISENHOWER.
Director of Finance	W. A. JUMP.
Solicitor	MASTIN G. WHITE.
Agricultural Adjustment Administration	CHESTER C. DAVIS, *Administrator.*
Bureau of Agricultural Economics	A. G. BLACK, *Chief.*
Bureau of Agricultural Engineering	S. H. MCCRORY, *Chief.*
Bureau of Animal Industry	JOHN R. MOHLER, *Chief.*
Bureau of Biological Survey	J. N. DARLING, *Chief.*
Bureau of Chemistry and Soils	H. G. KNIGHT, *Chief.*
Bureau of Dairy Industry	O. E. REED. *Chief.*
Bureau of Entomology and Plant Quarantine	LEE A. STRONG, *Chief.*
Office of Experiment Stations	JAMES T. JARDINE, *Chief.*
Food and Drug Administration	WALTER G. CAMPBELL, *Chief.*
Forest Service	FERDINAND A. SILCOX, *Chief.*
Grain Futures Administration	J. W. T. DUVEL, Chief.
Bureau of Home Economics	LOUISE STANLEY, Chief.
Library	CLARIBEL R. BARNETT, *Librarian.*
Bureau of Plant Industry	FREDERICK B. RICHEY, *Chief.*
Bureau of Public Roads	THOMAS H. MACDONALD, *Chief.*
Soil Conservation Service	H. H. BENNETT, *Chief.*
Weather Bureau	WILLIS R. GREGG, *Chief.*

This circular is a contribution from

Bureau of Animal Industry	JOHN R. MOHLER, *Chief.*
Animal Husbandry Division	H. C. MCPHEE, *Principal Animal Husbandman, Chief.*

U. S. GOVERNMENT PRINTING OFFICE: 1935

For sale by the Superintendent of Documents, Washington, D. C. - - - - - - Price 5 cents